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This is a request for filing a PROVISIONAL APPLICATION for PATENT under 37 CFR 1.53(c).

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TITLE OF THE INVENTION (280 characters max)

METHODS FOR DETECTING LP-PLA2 ACTIVITY AND INHIBITION OF LP-PLA2 ACTIVITY

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ENCLOSED APPLICATION PARTS (check all that apply)

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Respectfully submitted,
Signature: Andrea V. Lockenour

Date: 16 April 2004
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☐ Additional inventors are being named on separately numbered sheets attached hereto.

PROVISIONAL APPLICATION FILING ONLY

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20462

CUSTOMER NUMBER

Methods for Detecting Lp-PLA2 Activity and Inhibition of Lp-PLA2 Activity

Field of the Invention:

This invention relates generally to methods and materials for determining lipoprotein-associated phospholipase A2 (herein "Lp-PLA2") enzyme activity and inhibition of activity in tissue samples from animals.

Background of the Invention:

Coronary heart disease (herein "CHD") is the leading cause of death in many industrial countries. Atherosclerosis is a form of arteriosclerosis or hardening of the arteries in which there is the progressive build-up of plaque containing cholesterol and lipids in blood arteries. This build-up is associated with an increased risk of heart disease and morbid coronary events. The build-up of plaque in the arteries is associated with an immune response that is triggered by damage to the endothelium. Initially, monocyte-derived macrophages accumulate at the damaged site, due to the immune response causing a migration and accumulation of smooth muscle cells which form fibrous plaque in combination with the macrophages, lipids, cholesterol, calcium salts and collagen. The growth of such lesions can eventually block the artery and restrict blood flow.

Lp-PLA2, also known as PAF acetylhydrolase, is a secreted, calcium-independent member of the growing phospholipase A2 superfamily (Tew, *et al.* (1996) *Arterioscler Thromb Vasc Biol.* 16(4):591-9; Tjoelker, *et al.* (1995) *Nature* 374(6522):549-53). It is produced by monocytes, macrophages, and lymphocytes and is found associated predominantly with LDL (~80%) in human plasma. The enzyme cleaves polar phospholipids, including sn-2 ester of 1-O-alkyl-2-scetyl-sn-glycero-3-phosphocholine, otherwise known as platelet-activating factor (herein "PAF") (Tjoelker, *et al.* (1995) *Nature* 374(6522):549-53).

Many observations have demonstrated a pro-inflammatory activity of oxidized LDL when compared with native unmodified lipoproteins. One of the earliest events in LDL oxidation is the hydrolysis of oxidatively modified phosphatidylcholine, generating substantial quantities of lysophosphatidylcholine (herein "lyso-PC") and oxidized fatty acids. This hydrolysis is mediated solely by

Lp-PLA2 (i.e., Lp-PLA2 hydrolyzes PAF to give lyso-phosphatidylcholine [herein "lyso-PC"] and acetate). (Stafforini, *et al.* (1997) *J. Biol. Chem.* 272, 17895)

Lyso-PC is suspected to be a pro-inflammatory and pro-atherogenic mediator. In addition to being cytotoxic at higher concentrations, it is able to stimulate monocyte and T-lymphocyte chemotaxis, as well as induce adhesion molecule and inflammatory cytokine expression at more modest concentrations. Lyso-PC has also been identified as the component of oxidized LDL that is involved in the antigenicity of LDL, a feature that may also contribute to the inflammatory nature of atherosclerosis. Moreover, lyso-PC promotes macrophage proliferation and induces endothelial dysfunction in various arterial beds. The oxidized fatty acids that are liberated together with lyso-PC are also monocyte chemoattractants and may also be involved in other biological activities such as cell signaling). Because both of these products of Lp-PLA2 hydrolysis are potent chemoattractants for circulating monocytes, Lp-PLA2 is thought to be responsible for the accumulation of cells loaded with cholesterol ester in the arteries, causing the characteristic "fatty streak" associated with the early stages of atherosclerosis.

Lp-PLA2 has also been found to be enriched in the highly atherogenic lipoprotein subfraction of small dense LDL, which is susceptible to oxidative modification. Moreover, enzyme levels are increased in patients with hyperlipidaemia, stroke, Type 1 and Type 2 diabetes mellitus, as well as in post-menopausal women. As such, plasma Lp-PLA2 levels tend to be elevated in those individuals who are considered to be at risk of developing accelerated atherosclerosis and clinical cardiovascular events. Thus, inhibition of the Lp-PLA2 enzyme would be expected to stop the build up of this fatty streak (by inhibition of the formation of lysophosphatidylcholine), and so be useful in the treatment of atherosclerosis.

Lp-PLA2 inhibitors inhibit LDL oxidation. Lp-PLA2 inhibitors may therefore have a general application in any disorder that involves lipid peroxidation in conjunction with the enzyme activity, for example in addition to conditions such as atherosclerosis and diabetes other conditions such as rheumatoid arthritis, stroke, myocardial infarction (Serebruany, *et al. Cardiology.* 90(2):127-30 (1998)); reperfusion injury and acute and chronic inflammation. In addition, Lp-PLA2 is currently being explored as a biomarker of coronary heart disease (Blankenberg, et

al. J Lipid Res. 2003 May 1) and arteriosclerosis (Tselepis and Chapman. *Atheroscler Suppl.* 3(4):57-68 (2002)). Furthermore, Lp-PLA2 has been shown to play a role in the following disease: respiratory distress syndrome (Grissom, *et al. Crit Care Med.* 31(3):770-5 (2003); immunoglobulin A nephropathy (Yoon, *et al. Clin Genet.* 62(2):128-34 (2002); graft patency of femoropopliteal bypass (Unno, *et al. Surgery* 132(1):66-71(2002); oral inflammation (McManus and Pinckard. *Crit Rev Oral Biol Med.* 11(2):240-58 (2000)); airway inflammation and hyperreactivity (Henderson, *et al. J Immunol.* 15;164(6):3360-7 (2000)); HIV and AIDS (Khovidhunkit, *et al. Metabolism.* 48(12):1524-31 (1999)); asthma (Satoh, *et al. Am J Respir Crit Care Med.* 159(3):974-9 (1999)); juvenile rheumatoid arthritis (Tselepis, *et al. Arthritis Rheum.* 42(2):373-83 (1999)); human middle ear effusions (Tsuji, *et al. ORL J Otorhinolaryngol Relat Spec.* 60(1):25-9 (1998)); schizophrenia (Bell, *et al. Biochem Biophys Res Commun.* 29;241(3):630-5 9 (1997)); necrotizing enterocolitis development (Muguruma, *et al. Adv Exp Med Biol.* 407:379-82 (1997)); and ischemic bowel necrosis (*Pediatr Res.* 34(2):237-41(1993)).

Lp-PLA2 activity from human tissue samples has been measured using spectrophotometric activity and fluorogenic activity assays (Cayman Chemical Company, and Karlan Research Products). See also Kosaka, *et al. Clin Chem Acta* 296(1-2):151-61 (2000) and Kosaka, *et al. Clin Chem Acta* 312(1-2):179-83 (2001). For instance, Azwell, Inc. (Osaka, Japan) reported in 2000 the synthesis and use of 1-myristoyl-2-(p-nitrophenylsuccinyl) phosphatidylcholine as a colorimetric substrate for measurement of human PAF AH (Lp-PLA2) activity in plasma and serum. In 2002, Azwell launched its research-use-only Auto PAF AH assay kit that utilizes this substrate and is formatted for use in a clinical chemistry analyzer. These methods may be capable of detecting inhibition of Lp-PLA2 activity when an inhibitor of Lp-PLA2 is added to a tissue sample *in vitro*. However, the methods provided with the Auto PAF AH assay are insensitive to measuring inhibition of Lp-PLA2 activity when an inhibitor of Lp-PLA2 has been administered to an animal prior to tissue sample collection.

In order to measure Lp-PLA2 activity in the presence of inhibitor in a tissue sample obtained from an animal administered inhibitor, an activity protocol is required. Accordingly, methods for determining LP-PLA2 activity and inhibition

from a tissue sample obtained from an animal that has been administered an Lp-PLA2 inhibitor are greatly needed.

Summary of the Invention

In one aspect of the present invention, a method is provided for determining inhibition of Lp-PLA2 enzyme activity in at least one tissue sample comprising the steps of preparing a solution comprising a substrate for Lp-PLA2 comprising a colorimetric or fluorometric detectable moiety; contacting at least one said tissue sample with the solution of the preparing step; and detecting Lp-PLA2 activity, wherein the tissue sample is from an animal that has been administered with Lp-PLA2 inhibitor.

In another aspect of the current invention, a method is provided for determining Lp-PLA2 enzyme activity in a tissue sample obtained from an animal comprising the steps of:

a) contacting 110 μL of a solution comprising:
   a solution comprising 90 mM 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine contacted with a solution comprising 200mM HEPES, 200mM NaCl, 5mM EDTA, 10mM CHAPS, 10mM sodium 1-nonanesulfonate at a pH 7.6 in a ratio of 0.66 μL to 110 μL;
   with at least one 25 μL tissue sample from an animal;
   with 25 μL each of a p-nitrophenol standard solution comprising; 4, 3, 2, 1, 0.4 or 0.2 nmol/μL p-nitrophenol in methanol; and
   25 μL of phosphate buffered saline (PBS) or ddH_2O to make a blank; and
b) determining Lp-PLA2 activity.

Detailed Description of the Invention

Glossary

"Animal" as used herein includes any human or non-human mammal, or any other vertebrate capable of naturally producing an enzyme having Lp-PLA2 activity, including Lp-PLA2, Lp-PLA2- homologs or orthologs thereof.

"Clinical trial" means human clinical trial.

"Lp-PLA2 enzyme activity" as used herein includes, but is not limited to, any enzyme activity of Lp-PLA2. This activity may include but is not limited to an Lp-PLA2 enzyme binding substrate, releasing product, and/or hydrolyzing phospholipids or other molecules.

"Polypeptide(s)" refers to any peptide or protein comprising two or more amino acids joined to each other by peptide bonds or modified peptide bonds. "Polypeptide(s)" refers to both short chains, commonly referred to as peptides, oligopeptides and oligomers and to longer chains generally referred to as proteins. Polypeptides may comprise amino acids other than the 20 gene encoded amino acids. "Polypeptide(s)" comprise those modified either by natural processes, such as processing and other post-translational modifications, but also by chemical modification techniques. Such modifications are well described in basic texts and in more detailed monographs, as well as in a voluminous research literature, and they are well known to those of skill in the art. It will be appreciated that the same type of modification may be present in the same or varying degree at several sites in a given polypeptide. Also, a given polypeptide may comprise many types of modifications. Modifications can occur anywhere in a polypeptide, including the peptide backbone, the amino acid side-chains, and the amino or carboxyl termini. Modifications comprise, for example, acetylation, acylation, ADP-ribosylation, amidation, covalent attachment of flavin, covalent attachment of a heme moiety, covalent attachment of a nucleotide or nucleotide derivative, covalent attachment of a lipid or lipid derivative, covalent attachment of phosphotidylinositol, cross-linking, cyclization, disulfide bond formation, demethylation, formation of covalent cross-links, formation of cysteine, formation of pyroglutamate, formylation, gamma-carboxylation, GPI anchor formation, hydroxylation, iodination, methylation, myristoylation, oxidation, proteolytic processing, phosphorylation, prenylation, racemization, glycosylation, lipid attachment, sulfation, gamma-carboxylation of glutamic acid residues, hydroxylation and ADP-ribosylation, selenoylation, sulfation, transfer-RNA mediated addition of amino acids to proteins, such as arginylation, and ubiquitination. See, for instance, PROTEINS - STRUCTURE AND MOLECULAR PROPERTIES, 2nd Ed., T. E. Creighton, W. H. Freeman and Company, New York (1993) and Wold, F., Posttranslational Protein Modifications: Perspectives and Prospects, pgs. 1-12 in POSTTRANSLATIONAL COVALENT

MODIFICATION OF PROTEINS, B. C. Johnson, Ed., Academic Press, New York (1983); Seifter et al., Meth. Enzymol. 182:626-646 (1990) and Rattan et al., Protein Synthesis: Posttranslational Modifications and Aging, Ann. N.Y. Acad. Sci. 663: 48-62 (1992). Polypeptides may be branched or cyclic, with or without branching. Cyclic, branched and branched circular polypeptides may result from post-translational natural processes and may be made by entirely synthetic methods, as well.

"Filtration" or "filtering" as used herein includes, but is not limited to, the removal of any substance from a solution and may comprise passing a solution containing the substance to be removed through filter paper, Whatman paper, cheese cloth, or a column that selectively removes said substance from solution based on its physical and/or chemical characteristics. Physical and chemical characteristics that may be used to remove a substance through filtration may include, but are not limited to, ionic charge, size, weight, polarity, and/or chemical moieties associated with the substance that make it likely to bind to the material filling the column. Filtration may comprise using gravity, vacuum, and/or centrifugation to facilitate the removal of said substance from solution.

"Scintillation cocktail" as used herein is a mixture of solutes and solvents, typically containing an organic solvent capable of solubilizing and maintaining a uniform suspension of a tissue sample for liquid scintillation. The process of liquid scintillation involves the detection of beta decay within a sample via capture of beta emissions. A scintillation cocktail mixture is designed to capture the beta emission and transform it into a photon emission which can be detected via a photomultiplier tube within a scintillation counter. Several scintillation cocktails are commercially available. It is understood that a modification of the composition of the scintillation cocktail can effect and/or optimize the detectable reading from liquid scintillation depending on the sample.

"Tissue(s)" as used herein comprises serum, cell lysate, tissue lysate, urine, blood plasma, plaque, monocytes, or macrophage cells. These tissues can be from humans, non-human mammals or other animals that naturally produces and enzyme having Lp-PLA2 activity, including Lp-PLA2, Lp-PLA2- homologs or orthologs thereof.

"Colorimetric or fluorimetrc detectable moiety" as used herein is a portion of a compound capable of producing a detectable or measurable signal. Such a signal may be measurable by, but not limited to, visible light emission or absorption, fluorescence, phosphorescence or other detectable quanta. For instance, a substrate for Lp-PLA2 may comprises a colorimetrc moiety bonded to phosphatidylcholine at the Lp-PLA2 cleavage site. When Lp-PLA2 cleaves the colorimetric moiety from phosphatidylcholine the colorimetric moiety emits a detectable signal as visible light. One non-limiting example of phosphatidylcholine bonded to a colorimetric moiety is 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine.

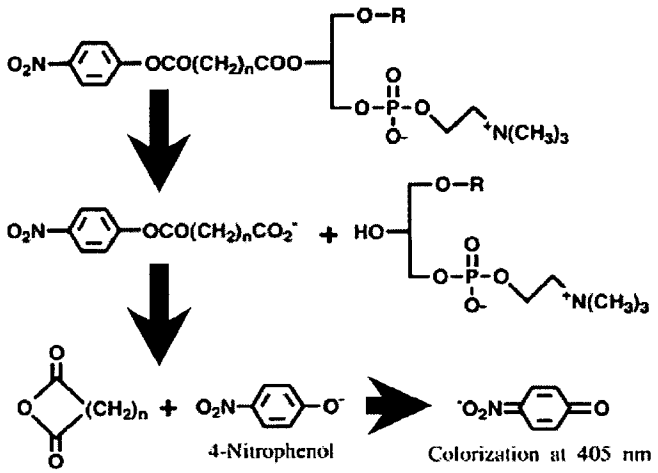
Lp-PLA2 "inhibitor" or "inhibition" as used herein refers to any method, technique, condition, or compound capable of reducing or eliminating Lp-PLA2 activity, including but not limited to reducing or eliminating any of the activities of Lp-PLA2 including, but not limited to, enzyme binding substrate, releasing product, and/or hydrolyzing phospholipids or other molecules. Inhibition of Lp-PLA2 activity may be measured in a sample obtained from an animal administered an inhibitor, which is considered *in vivo* administration. Alternatively, an inhibitor may be added to a sample after it is obtained from an animal, which would be considered *in vitro* administration.

As used herein, "reduce" or "reducing" refers to a decrease or elimination in Lp-PLA2 enzyme activity. Some non-limiting examples for the purposes of measuring reduced Lp-PLA2 activity include measuring Lp-PLA2 activity from the same animal in the presence and absence of an inhibitor of Lp-PLA2 activity. Alternatively, Lp-PLA2 activity can be measured against a standard recombinantly expressed, semi-purified or purified enzyme.

As used herein "free" or "essentially free" of Lp-PLA2 inhibitor refers to a tissue sample that contains either no Lp-PLA2 inhibitor or Lp-PLA2 inhibitor at a low enough concentration such that Lp-PLA2 activity is not inhibited by the inhibitor. For instance, if the inhibitor is present at a concentration lower than the determined dissociation constant of that inhibitor for Lp-PLA2, a tissue sample may be considered essentially free of inhibitor. A tissue sample may be considered free of Lp-PLA2 inhibitor if it is obtained from an animal prior to administration of an Lp-PLA2 inhibitor that is not produced naturally by the animal. A tissue sample may also be considered free or essentially free of an Lp-PLA2 inhibitor if it is

obtained from an animal at a time after the last dose of inhibitor sufficient to ensure clearance based on pharmacokinetic profile of that inhibitor in the species of animal.

Lp-PLA2 is a known hydrolyzer of phospholipids. Lp-PLA2 can cleave phospholipids at the sn-2 position to create lyso-PC and oxidized fatty acids. PAF has a two-carbon acyl group at the sn-2 position; therefore, when PAF is hydrolyzed by Lp-PLA$_2$, the short acyl group is cleaved as water soluble acetate from the remainder of the molecule, which is lyso-PC. A substrate possessing a colorimetric or fluorimetrc moiety can be used to measure Lp-PLA2 activity. For instance, the substrate, 1-myristoyle-2-(p-nitrophenylsuccinyl)-phosphatidylcholine, is a PAF analogue with a 4-nitrophenyl group conjugated onto a succinyl chain at sn-2 position. Lp-PLA2 (PAF-AH) hydrolyzes the sn-2 position of the substrate, producing 4-nitrophenyl succinate. This liberation can be spectrophotometrically monitored at 405nm and Lp-PLA2 activity determined from the change in absorption.



The methods of the present invention have been shown to demonstrate a correlation between Lp-PLA2 inhibitor concentration in a tissue sample and Lp-PLA2 activity *in vitro*. Furthermore, the present invention provides methods for measuring Lp-PLA2 activity over time in tissue samples from animals treated with Lp-PLA2 inhibitor. These data may be correlated with the pharmacokinetic profile of inhibitor from an animal, such as a human.

A colorimetric Lp-PLA2 activity monitoring assay has been developed using 1-myristoyl-2-(p-nitrophenylsuccinyl) phosphatidylcholine as the substrate. *In vitro* drug inhibition study using Lp-PLA2-specific inhibitors showed specificity of this substrate against Lp-PLA2. However, the Auto PAF AH assay provided by Azwell failed to detect drug inhibition in human subjects who received Lp-PLA2 inhibitor drugs *in vivo*, although the same substrate and the same buffer condition are used in the assays developed herein. Factors such as pre-incubation of plasma with assay buffer, plasma sample volume, substrate concentration, and use of buffer R2A, have been identified to contribute to *in vitro* drug dissociation in the assay and in turn cause the inability of the assay to detect drug inhibition in *in vivo* drug-bound tissue samples. These factors therefore were modified in development of new, drug-sensitive colorimetric Lp-PLA2 activity assays. Interactions between these factors have also been studied so that assay conditions could be chosen that would generate detectable *in vivo* drug inhibition and also offer an assay dynamic range. This modified drug-sensitive assay is able to detect 85-90% drug inhibition in human subjects with *in vivo* administration of Lp-PLA2 inhibitors and therefore could be used as a monitoring assay to assess drug efficacy in the clinic. This assay also offers a dynamic range of close to 100-fold and potentially is also useful as a screening assay that is capable of measurement of a broader range of Lp-PLA2 activity.

In one aspect of the present invention, a method is provided for determining inhibition of Lp-PLA2 enzyme activity in at least one tissue sample comprising the steps of preparing a solution comprising a substrate for Lp-PLA2 comprising a colorimetric or fluorometric detectable moiety; contacting at least one said tissue sample with the solution of the preparing step; and detecting Lp-PLA2 activity, wherein the tissue sample is from an animal that has been administered with Lp-PLA2 inhibitor. These methods may further comprise comparing Lp-PLA2 activity from a tissue sample obtained from an animal prior to Lp-PLA2 inhibitor administration or that is free of Lp-PLA2 inhibitor. Inhibition of Lp-PLA2 activity may be measured in a plurality of tissue samples obtained from an animal at more than one time point after administration of said Lp-PLA2 inhibitor. The substrate may be 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine and may be

used at a concentration of about 154 μM to about 1125 μM. The concentration of -myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine may be 440 μM.

In one aspect of the invention, the tissue sample is blood plasma. In another aspect, the blood plasma is diluted about 3 to 9 fold with the solution of the preparing. Lp-PLA2 activity may be measured by measuring optical density of the tissue sample.

In another aspect of the present invention, the solution comprising a substrate for Lp-PLA2 further comprises a buffer and wherein the buffer is incubated with the substrate prior to contacting the substrate with said tissue sample. In another aspect, the buffer does not comprise citric acid monohydrate. In another aspect, the substrate concentration is maintained at approximately the Km of said substrate. Km of said substrate may be decreased by removing citric acid monohydrate from the buffer. When the substrate is 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine, the substrate concentration is about 440 μM.

In another aspect of the present invention, the volume of plasma sample is about 15 μL to about 50 μL in a volume of about 125 μL to about 170 μL of the solution of the preparing step. In another aspect, the pH of the reaction is maintained at at least about 7.5 prior to contacting the plasma sample with the solution of the preparing step.

In another embodiment of the present invention, a method is provided for determining Lp-PLA2 enzyme activity in a tissue sample obtained from an animal comprising the steps of:

a) contacting 110 μL of a solution comprising:
   a solution comprising 90 mM 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine contacted with a solution comprising 200mM HEPES, 200mM NaCl, 5mM EDTA, 10mM CHAPS, 10mM sodium 1-nonanesulfonate at a pH 7.6 in a ratio of 0.66 μL to 110 μL;
   with at least one 25 μL tissue sample from an animal;
   with 25 μL each of a p-nitrophenol standard solution comprising; 4, 3, 2, 1, 0.4 or 0.2 nmol/μL p-nitrophenol in methanol; and
   25 μL of phosphate buffered saline (PBS) or ddH_2O to make a blank; and

b) determining Lp-PLA2 activity.

In one aspect, the tissue sample from animal is blood plasma. In another aspect, the animal is human. In yet another aspect, the animal has been administered an inhibitor of Lp-PLA2 prior to obtaining the tissue sample. Inhibition of Lp-PLA2 enzyme activity by said Lp-PLA2 inhibitor administered prior to obtaining said tissue sample is measured by comparing Lp-PLA2 activity of a tissue sample free of said Lp-PLA2 inhibitor.

In another embodiment of the present invention, a method is provided for determining Lp-PLA2 enzyme activity in a tissue sample obtained from an animal wherein enzyme activity is determined by:

a) generating a standard curve by plotting optical density (OD) values at 405 nm for the p-nitrophenol standard solutions vs. p-nitrophenol (nmol/well);

b) calculating the slope (OD/nmol) of the standard curve;

c) calculating aborbance change between 3 and 1 minute ($\Delta OD_{3min-1min}$) for both solutions comprising tissue samples and blank; and

d) calculating Lp-PLA2 activity using the following formula: Lp-PLA2 activity (nmol/min/ml) = (ΔOD_{sample} -ΔOD_{blank}) ÷ slope (OD/nmol) ÷ 0.025 ml ÷ 2 minutes.

In another embodiment of the present invention, a method is provided for determining Lp-PLA2 enzyme activity in a tissue sample obtained from an animal comprising the steps of:

a) preparing a solution comprising 200mM HEPES, 200mM NaCl, 5mM EDTA, 10mM CHAPS, 10mM sodium 1-nonanesulfonate at a pH 7.6;

b) preparing a solution comprising 90 mM 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine;

c) preparing 100, 75, 50, 25, 10 and 5 nmol/μL stock solutions of p-nitrophenol in methanol;

d) preparing working solutions for p-nitrophenol standards by diluting 40 μL of stock solutions of step c into 960 μL of methanol;

e) contacting the solution of step b and the solution of step a in a ratio of 0.66 μL to 110 μL to make an assay buffer;

f) adding 120 μL of assay buffer to each well in a 96-well V-bottom plate;

g) adding 25 μL of each p-nitrophenol standard working solution of step d into a separate well of two columns of a 96-well flat-bottom plate;

h) adding 25 μL of tissue sample from an animal per well that do not contain p-nitrophenol standards of the flat-bottom plate of step g;

i) adding 25 μL of PBS or dd H_2O into an empty well in the flat-bottom plate for use as a blank;

j) contacting 110 μL of assay buffer from the V-bottom plate to each well of the flat-bottom assay plate;

k) placing the flat bottom assay plate onto a plate reader and reading at 405 nm;

l) generating a standard curve by plotting optical density (OD) values for the standard solutions vs. p-nitrophenol (nmol/well);

m) calculating the slope (OD/nmol) of the standard curve;

n) calculating absorbance change between 3 and 1 minutes ($\Delta OD_{3min-1min}$) for both test samples and the blank; and

o) calculating Lp-PLA2 activity using the following formula: Lp-PLA2 activity (nmol/min/ml) = (ΔOD_{sample} -ΔOD_{blank}) ÷ slope (OD/nmol) ÷ 0.025 ml ÷ 2 minutes.

The following examples illustrate various aspects of this invention. These examples do not limit the scope of this invention which is defined by the appended claims.

Examples

Unless otherwise indicated all plasma samples were collected from human and are human plasma. Unless otherwise indicated, plasma samples for the following examples were collected as follows. Blood was collected into EDTA-containing tubes. The tubes were centrifuged at 1730 x g for 10 minutes. Plasma was drawn off with transfer pipettes into tubes and stored at -80°C.

In experiments in which Lp-PLA2 inhibitor was added to tissue samples *in vitro* the following procedure was used, unless otherwise indicated. A 1 mg/mL (1.5 mM) stock solution was prepared in HEPES/NaCl buffer. A series of working dilutions were prepared in HEPES/NaCl to give concentrations of 15,000, 10,000, 3330, 1110, 500, 370, 120, 40, 10, and 0 nM (For addition of the inhibitor solution to the reaction mixtures, 20 µL aliquots of each working dilution were used). The final concentrations of Lp-PLA2 inhibitor (in nM) were: 1500, 1000, 333, 111, 50, 37, 12, 4, 1, and 0.

Example 1: The Auto PAF AH Assay Kit

The Auto PAF AH assay kit manufactured by Azwell (Osaka, Japan) is commercially available in the United States through Karlan Research Products Corporation (Santa Rosa, CA). This assay was evaluated on an Olympus Au640 clinical chemistry analyzer and is described in this Example 1.

Materials

Azwell Auto PAF-AH Assay Kit:

R1: 200mM HEPES, 200 mM NaCl, 5mM EDTA, 10mM CHAPS, 10mM sodium 1-nonanesulfonate, pH 7.6

R2A: 20mM citric acid monohydrate, 10mM sodium 1-nonanesulfonate, pH 4.5

R2B: 90mM 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine

Assay Procedure

1. Enter assay parameters from the following table into the Olympus Au640 analyzer, and create a PAF AH assay program:

Sample volume: 2 µL
Reagent 1: 240 µL
Reagent 2: 80 µL
Wavelength (main): 410nm
Wavelength (sub): 480nm
Method: Rate
Point 1 (FST): 14
Point 1 (LST): 21

Calibration Type: MB
Formula: Y=AX+B
Counts: 2
MB Type Factor: 11595

2. Prepare the following reagents:
   R1: Use this buffer solution as supplied in Azwell Auto PAF AH assay kit. Store at 4°C. Protect from light.
   R2: Prepare the R2 working solution by mixing R2A and R2B (supplied in Azwell Auto PAF AH assay kit) in the proportion of 19:1. Store at 4°C. Protect from light.
3. Aliquot 30 μL or more of each plasma sample into a 2 mL Sarstedt micro-tubes (Sarstedt Incorporation, part No. 72.694.007). Briefly centrifuge to spin down fibrin clots/particles in the plasma.
4. Place Sarstedt tubes containing plasma samples onto sample tubes that fit the instrument. Run plasma samples through the Au640 analyzer. After choosing the PAF AH assay program, the analytical procedure described below is performed automatically:

Test sample (2 μL) + R1 (240 μL), 37°C, 5 minutes [0-5minutes]
Add R2 (80 μL), 37°C, 5 minutes [5-10 minutes]
Measure the absorbance at 410nm and 480nm [6-8 minutes]
Calculate PAF AH activity (IU/L)

5. Include Bio-Rad Lyphochek Assayed Chemistry Control Level 1 and Level 2 (C-310-5 and C-315-5, Bio-Rad, Hercules, CA) as quality controls in each run. The Lp-PLA2 activity values for these two controls are within the range of normal human plasma Lp-PLA2.

Example 2: High Throughput Radiometric Assay for Measurement of Lp-PLA2 Activity

A high throughput radiometric assay was developed for measuring Lp-PLA2 activity in a sample. This assay is fully described in U.S. Patent Application No. 60/473777. A summary of a high throughput radiometric activity assay is provided in this Example 2.

Equipment

Scintillation Counter	TopCount Microplate Scintillation and Luminescence Counter, Perkin-Elmer (formerly Packard), CA
Centrifuge	Allegra 25R benchtop centrifuge, Beckman Coulter, CA
Plate shaker	Lab-Line Titer Plate Shaker (VWR cat #57019-600)
Oven	Barnstead/Thermolyne, series 9000, temperature range 10-250° C (VWR cat#52205-065)
12-channel Pipettors	BRAND Transferpette® -12, BrandTech Scientific, Inc., Essex, CT

Material

Polypropylene Plates	Costar* Brand 96-Well Plates, Polypropylene, Nonsterile, Without Lids, Costar 3365, Corning, Inc., Corning, NY (VWR cat #29444-104)
PicoPlate Plates	96-Well white solvent-resistant microplates, Perkin Elmer Life Sciences, Inc, Boston, MA (cat #6005162)

Reagents

HEPES (4-(2-hydroxyethyl)-1-piperazineethane sulfonic acid) Sigma Chemical Co., St. Louis MO. (Cat # H9897100)

Sodium Chloride, Sigma Chemical Co., St. Louis MO. (Cat # S5150; 5.0 M)

EDTA, Sigma Chemical Co., St. Louis MO. (Cat # E7889; 0.5 M)

^{3}H-Platelet Activating Factor, 1-O-Hexadecyl-[acetyl-^{3}H(N)], (^{3}H-PAF) - NEN Life Science Products, Roxbury, MA (Cat # NET-910, supplied as an ethanol solution, typically 0.1 mCi/mL; 250uCi)

C16-PAF, (1-hexadecyl-2-acetyl- *sn*-glycero-3-phosphocholine): Avanti Polar Lipids, Alabaster, AL (Cat #878110; 5.0 mg/ml)

MicroScint-20: Perkin Elmer Biosciences, Boston, MA (cat # 6013621)

Fatty acid-free bovine serum albumin (BSA): Sigma Chemical Co., St. Louis MO. (Cat # A0281; 1.0 gm)

Trichloroacetic acid (TCA): Sigma Chemical Co., St. Louis MO. (Cat # T9159)

Assay Buffer

100 mM Hepes, pH 7.4

150 mM NaCl

5 mM EDTA

Store it at room temperature

Procedures

1. Prepare a ^{3}H-PAF working solution (for 100 reactions):
   a) Aliquot 480 µl ^{3}H-PAF (10 µM = 0.1 mCi/ml at 10.0 Ci/mmol) and 125.3 µl of [C16]PAF (5.0 mg/ml; MW: 524) to a tube;
   b) Mix and air dry in the hood;
   c) Resuspend the dried pellets in 12.0 ml of assay buffer giving working solutions of 100 µM PAF (i.e. ^{3}H-PAF at 0.4 µM and cold [C16]PAF at 99.6 µM);
2. Aliquot 5 µL of assay buffer (for Total counts and Blanks; n = 8) or plasma samples in duplicates into a 96-well plate;
3. Equilibrate the plate to 21° C;
4. Add 100 µL of the ^{3}H-PAF solution to each well, mix and incubate the plate at 21° C for 5 minutes;
5. Add 50 µL of ice-cold BSA solution (50 mg/ml) to all wells, mix and incubate the plate in a refrigerator for 5 minutes;
6. Add 25 µL of ice-cold TCA solution (56%) to each well, mix and incubate the plate in a refrigerator for 15 minutes;
7. Centrifuge the plate at 6,000 g for 15 minutes at 4° C;
8. Aliquot 45 µL of the supernatants to a 96-well polystyrene plate;
9. Add 10 µL of ^{3}H-PAF working solution to 6 Total Counts wells;

10. Add 200 µL of MicroScint-20 scintillation cocktail to each well;
11. Cover the plate with a plate tape and vortex mix at max speed for 10 minutes;
12. Get static off the plate by wiping with a wet tissue and drying with another clean one;
13. Count with a TopCount scintillation counter for 2 minutes each; and
14. Calculate Lp-PLA2 activity:

$$\text{Lp-PLA2 activity (nmoles/min/ml)} = 160 * (CPM_{45\mu l\text{-supe}} - CPM_{Blanks})/(CPM_{10\mu l\text{-spiking}} - CPM_{Blanks})$$

Where $CPM_{45\mu l\text{-supe}}$ is the average count from each sample

CPM_{Blanks} is the average count of the Blanks

$CPM_{10\mu l\text{-spiking}}$ is the average count of the Total Counts

Example 3: Correlation of Auto PAF AH assay and High Throughput Radiometric Assay

A panel of 120 plasma samples from healthy human volunteers was assayed for Lp-PLA2 activity at three clinics using the high-throughput radiometric assay described in Example 2. The same sample panel was assayed using Azwell's Auto PAF AH assay described in Example 1 on the Olympus Au640 analyzer. Correlation was obtained against data generated on the same panel of samples by the high throughput radiometric. Correlation coefficients (r) were 0.96, 0.94, and 0.95 for Azwell vs. the radiometric activity assay at the three clinics, respectively. The average CV between duplicates was 2.14% for the Azwell assay.

Example 4: Low Throughput Radiometric Assay

A low throughput radiometric assay capable of measuring Lp-PLA2 activity is provided below.

Materials

Scintillation Vials	Wheaton Omni Vials, Millville, NJ (Cat # 225402)
Scintillation Fluid	EcoLite™, ICN, Costa Mesa, CA (Cat # 882475)

Equipement

Beta Counter	Beckman Liquid Scintillation Counter, LS 5000TA, Beckman Instruments, Fullerton, CA
Water Bath	Fisher Scientific, Edison, NJ
Microcentrifuge	Jouan Inc., Winchester, VA, Model No. A-14

Reagents

HEPES (4-(2-hydroxyethyl)-1-piperazineethane sulfonic acid)	Sigma Chemical Co., St. Louis MO (Cat # H 9136)
Sodium Chloride	Sigma Chemical Co., St. Louis MO (Cat # S 7653)
Chloroform	Aldrich Chemical Co., Milwaukee, WI (Cat # 36,692-7)
Methanol	Aldrich Chemical Co., Milwaukee, WI (Cat # 27,047-4)
^{3}H-Platelet Activating Factor, 1-O-Hexadecyl-[acetyl-^{3}H(N)], (^{3}H-PAF)	NEN Life Science Products, Roxbury, MA (Cat # NET-910, supplied as an ethanol solution, typically 0.1 mCi/mL)
C16-PAF, (1-hexadecyl-2-acetyl-*sn*-glycero-3-phosphocholine)	Avanti Polar Lipids, Alabaster, AL (Cat # 878110, supplied as 5 mg/mL $CHCl_3$ solution)

Assay Buffer

HEPES/NaCl Buffer: 50 mM HEPES, 150 mM NaCl, pH 7.4 at 37°C.

Assay Solutions

^{3}H-PAF working solution: Pipette 5 μCi (typically 50 μL of the solution supplied by the vendor) of ^{3}H-PAF stock solution into a 1.4 mL glass vial. Add 340 ug (68 μL of a 5 mg/mL solution) of C16-PAF. Evaporate to dryness under a gentle stream of nitrogen gas in a fume hood. Reconstitute with 1.3 mL of HEPES/NaCl buffer. This will prepare sufficient working solution for approximately 62 assay tubes.

Assay Master Mix: In a 15 mL polypropylene tube, combine 7.3 mL of HEPES/NaCl buffer and 1.1 mL of ^{3}H PAF working solution. In the final reaction mixture, after addition of the plasma sample, the final concentration of PAF (unlabelled C16-PAF + ^{3}H-PAF) is 50 uM (the 200 μL reaction volume contains 10 nmols PAF).

For testing the inhibition of LpPLA2 activity in plasma, the assay was performed as follows:

(1) 110 μL HEPES/NaCl buffer + 20 μL of appropriate working dilution of Lp-PLA2 inihibitor + 50 μL of plasma sample were added to a 1.5 mL microcentrifuge tube and incubated at 37°C for 15 minutes.

(2) 20 μL of 3H-PAF working solution was added and the samples were incubated at 37°C for 30 seconds.

(3) Reactions terminated by the addition of 600 μL of $CHCl_3/CH_3OH$ and processed by the assay procedures described herein.

Assay Procedures

1. Thaw plasma samples and place in 37°C water bath to temperature equilibrate.
2. Add 150 μL of assay master mix to 1.5 mL polypropylene tubes and place in 37°C water bath. Allow 5 minutes for temperature equilibration.
3. Add 50 μL of plasma sample or 50 μL of HEPES/NaCl buffer for buffer blanks (all samples are assayed in duplicate) to appropriate tubes containing assay master mix, vortex briefly, and incubate for 30 seconds in the 37°C water bath.
4. Stop reaction by addition of 600 μL of $CHCl_3/CH_3OH$ solution and vortex well.
5. Just prior to centrifuging, briefly re-vortex the samples. Separate organic and aqueous phases by centrifugation in a microcentrifuge at maximum speed for 2 minutes.
6. Collect 250 μL of the upper, aqueous phase and transfer to a new 1.5 mL polypropylene tube.
7. Add 250 μL of $CHCl_3$ and vortex well.
8. Separate organic and aqueous phases by centrifugation in a microcentrifuge at maximum speed for 1 minute.
9. Collect 150 μL of the upper, aqueous phase and transfer to a 7 mL scintillation vial.
10. Add 2 mL of EcoLite™ or equivalent liquid scintillation fluid.
11. Count samples in liquid scintillation counter using a counting program that has been set up to determine cpm, counting efficiency, and dpm.

12. For determination of total radioactivity in the reaction, duplicate 150 µL aliquots of the assay master mix are counted.

Data Reduction and Analysis

Either cpm or dpm values may be used for calculation of Lp-PLA_2 activity. If the counting efficiency is the same for the samples, buffer blanks, and total radioactivity vials, cpm values may be used. If different counting efficiencies are observed, dpm values should be used. For all of the results in this report, dpm values were used for activity calculations. The following equation is used to calculate $LpPLA_2$ activity (reported as nmols/min/mL) from the raw data:

$$((x - y) \div z) \times 40$$

where,

x = cpm (or dpm) of plasma sample x 1.65 (This corrects for the total volume of the aqueous phase in each extraction. This correction is necessary since only a portion of the aqueous phase is collected after each of the extractions.)

y = cpm (or dpm) of buffer blanks x 1.65 (average of duplicate determinations)

z = cpm (or dpm) of total radioactivity samples divided by 10 (there are 10 nmols of PAF in each reaction tube (average of duplicate determinations)

40 = factor to adjust results to nmol/min/mL (each reaction is for 30 seconds and the volume of plasma used in each reaction is 50 uL)

Example 5: Comparison of Inhibition of Lp-PLA2 Activity Measured by the Auto PAF AH assay and Low Throughput Radiometric Assay

Plasma was collected from six human subjects at different time points after *in vivo* drug administration of an Lp-PLA2 inhibitor during a clinical trial. Subjects #17 and #18 were dosed with 120mg of Formula I, described below, subjects #24 and #25 with 180mg, and subjects #21 and #22 with 240mg. Subjects #21 and #25 also received placebo on a different day. Lp-PLA2 activity was measured by the low throughput radiometric assay, described in Example 4, and >90% inhibition was observed with all six drug-treated subjects. However, Lp-PLA2 inhibition was not apparent when measured by the Auto PAF AH assay, as described in Example 1. The Auto PAF AH assay is insensitive to *in vivo* drug inhibition of Lp-PLA2. See Table 1 below.

Table 1: Measurement of Lp-PLA2 Activity in Patients Who Received Inhibitor *in vivo*

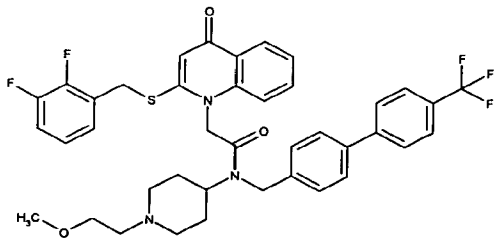
Time (hr)	Lp-PLA2 Activity (nmol/min/mL)											
	LTP Radiometric Assay						Auto PAF AH Assay					
	Drug #17	Drug #18	Drug #21	Drug #22	Drug #24	Drug #25	Drug #17	Drug #18	Drug #21	Drug #22	Drug #24	Drug #25
0	36.19	29.82	16.03	32.14	39.13	19.08	402	349	197	345	459	205
0.5	34.25	3.70	8.19	30.25	35.38	18.86	346	303	192	353	398	177
1	17.33	2.10	1.39	27.43	3.53	2.52	410	260	239	345	426	178
2	3.82	1.30	0.62	8.76	1.48	0.71	338	296	214	332	336	178
3	2.04	1.77	0.79	4.61	1.11	0.51	333	299	217	357	482	196
4	1.83	1.82	0.88	1.58	1.02	0.45	333	297	206	350	502	194
6	1.22	2.33	1.06	1.18	1.49	0.53	297	295	184	350	402	186
12	3.38	4.72	2.19	2.91	3.26	1.56	321	295	197	353	538	157
24	6.05	7.05	3.87	5.06	6.65	3.46	413	323	235	362	547	229
32	7.31	6.55	3.17	3.59	7.85	4.15	346	296	242	350	530	213
48	10.62	9.64	5.34	5.82	10.29	5.42	475	287	211	321	537	221
96	18.31	14.65	10.22	12.38	16.88	11.05	463	322	227	341	569	245
144	29.31	18.51	14.26	17.72	25.14	17.14	452	324	224	369	502	313

Inter-run and within-run variability for the Auto PAF AH assay on the Olympus Au640 has been consistently low with CV less than 5% between replicates. In this experiment, the average CV between duplicates was 2% for placebo samples and 3% for all drug samples. However, Lp-PLA2 activity measured by the Auto PAF AH assay fluctuated over time for both drug and placebo subjects. Similarly, radiometric activity values for the placebo subjects fluctuated over time with a higher %CV compared with the Auto PAF AH assay. Observed variability in Lp-PLA2 activity for the placebo subjects appears to be biological variability.

Table 2: Lp-PLA2 Activity (nmol/min/mL) in Patients who Received Placebo and Inhibitor *in vivo*

	Lp-PLA2 Activity (nmol/min/mL)					
	LTP Radiometric		Auto PAF AH		Auto PAF AH	
Time (hr)	Placebo #21	Placebo #25	Placebo #21	Placebo #25	Drug #21	Drug #25
0	23.50	22.10	231	238	197	205
0.5	26.15	23.11	227	246	192	177
1	18.97	23.69	237	246	239	178
2	25.99	27.10	233	245	214	178
3	27.07	33.33	247	260	217	196
4	28.71	12.14	219	267	206	194
6	25.31	24.97	216	232	184	186
12	25.54	25.11	238	252	197	157
24	28.40	27.09	250	268	235	229
32	24.96	31.86	294	275	242	213
48	25.50	24.72	233	279	211	221
96	14.34	23.38	256	347	227	245
144	27.03	30.30	271	247	224	313
Mean	24.73	25.30	242.46	261.69	214.23	207.08
Stdv.	3.96	5.27	21.57	29.37	18.62	40.01
% CV	16.00	20.85	8.89	11.22	8.69	19.32

Formula I, 2-(2-(3,4-Difluorophenyl)ethyl)-1 *H*-quinoline-4—1-yl *N*-(4'-trifluoromethylbiphenyl-4-ylmethyl)-acetamide bitartrate; is presented below and is described in WO 02/30904.

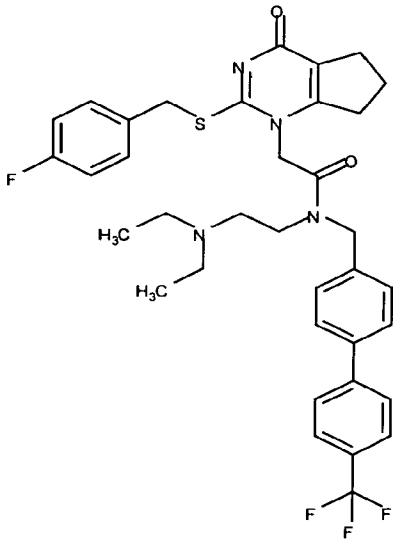


Formula I

Example 6: Comparison of Inhibition of Lp-PLA2 Activity Measured by the Auto PAF AH assay and Low Throughput Radiometric Assay

Plasma samples were evaluated from eight subjects who received 100 mg of a second Lp-PLA2 inhibitor during a clinical trial. The Lp-PLA2 inhibitor used in the study, 1-(N-(2-(Diethylamino)ethyl)-N-(4-(4-trifluoromethylphenyl)benzyl)-

aminocarbonylmethyl)-2-(4-fluorobenzyl)thio-5,6-trimethylenepyrimidin-4-one bitartrate, is described below as Formula II and is described in WO 01/60805:



Formula II

Four of the eight subjects also received placebo on a different day.

Greater than 90% inhibition of Lp-PLA2 activity was observed using the low throughput radiometric assay for *in vivo* administration of the Lp-PLA2 inhibitor. However, no inhibition was measured with the Auto PAF AH assay (see Table 3). Lp-PLA2 activity values fluctuated for both the drug and placebo subjects as measured by Auto PAF AH assay apparently due to biological fluctuation.

Table 3: Inhibition of LP-PLA2 Activity as Measured by Auto PAH AH and Low Throughput Radiometric Assay.

Timepoint (hr)	LTP Radiometric Assay							
	Drug #24	**Drug #25**	**Drug #26**	**Drug #27**	**Drug #28**	**Drug #29**	**Drug #30**	**Drug #31**
0	20.48	20.11	25.74	24.56	23.95	30.95	25.58	23.13
0.5	6.74	10.08	1.85	16.77	4.43	22.16	10.97	8.05
1	1.03	2.14	1.89	5.21	3.25	4.28	7.63	3.93
2	0.88	0.77	1.62	2.45	1.97	2.13	6.10	1.10
3	0.82	1.20	1.83	1.74	2.25	2.07	2.43	0.92
4	1.48	1.21	1.85	1.28	2.43	2.20	2.00	1.13
6	1.45	1.22	1.67	1.74	3.25	2.66	2.74	1.20
12	2.98	3.06	4.20	3.99	5.34	7.20	5.43	3.37
24	5.59	5.99	7.18	7.06	8.30	15.24	8.94	5.23
32	8.24	5.44	20.40	8.95	7.94	32.93	10.40	7.39
48	10.06	7.62	20.18	13.29	11.24	27.30	13.81	8.56
72	14.77	11.81	13.25	13.41	13.69	29.10	18.31	12.21
96	16.18	14.58	14.79	16.19	15.59	27.66	19.75	15.46
	Auto PAF AH Assay							
0	370	370	370	370	370	370	370	370
0.5	352	352	352	352	352	352	352	352
1	613	613	613	613	613	613	613	613
2	356	356	356	356	356	356	356	356
3	373	373	373	373	373	373	373	373
4	360	360	360	360	360	360	360	360
6	323	323	323	323	323	323	323	323
12	369	369	369	369	369	369	369	369
24	375	375	375	375	375	375	375	375
32	416	416	416	416	416	416	416	416
48	365	365	365	365	365	365	365	365
72	435	435	435	435	435	435	435	435
96	445	445	445	445	445	445	445	445

Example 7: Substrate Specificity Testing

A manual colorimetric Lp-PLA2 activity assay was developed using the substrate 1-myristoyl-2-(p-nitrophenylsuccinyl) phosphatidylcholine manufactured by Azwell (Osaka, Japan). This assay is a corresponding microtiter-plate version of the Auto PAF AH Assay compatible with a spectrophotometric plate reader. This manual assay was used to evaluate the physical properties of the substrate. Presented here are data on substrate specificity.

Materials

R1: 200mM HEPES, 200mM NaCl, 5mM EDTA, 10mM CHAPS, 10mM Sodium 1-nonanesulfonate, pH 7.6, Store at 4^0C.

R2A: 20mM citric acid monohydrate, 10mM sodium 1-nonanesulfonate, pH 4.5,

R2B: 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine, 90mM

p-nitrophenol: Sigma-Aldrich Chemical Co., St. Louis, MO (Cat #1048-25G)

Ethanol: Sigma-Aldrich Chemical Co., St. Louis, MO (Cat #7023)

Methanol: VWR International, West Chester, PA (Cat # EM-MX0482-6)

Reagent Preparation

R2: Mix R2A and R2B in ratio of 10:1. Store at 4^0C for no longer than two weeks before use.

p-Nitrophenol standards: Make 1M of 4-nitrophenol solution in Methanol. Dilute 100 µL, 75 µL, 50 µL, 25 µL, 10 µL, 5 µL of the1M solution in 1mL of Methanol to make 100, 75, 50, 25, 10, and 5 nmol/µL stock solution respectively. Make working solution for each standard by diluting 100 µL of stock solution into 900 µL of methanol (1:10 dilution). Store both stock and working solution at 4^0C.

Assay Procedure

1. Set temperature of the plate reader (SPECTRAmax® PLUS^{384} UV/VIS Microplate Spectrophotometer, Molecular Devices, Sunnyvale, CA) at 21^0C.
2. Add 120 µL of R1 into each well in a 96-well flat-bottom assay plate (Costar 3595, Corning, Inc., Corning, NY) using a multi-channel pipettor.
3. Add 10 µL of p-nitrophenol standard working solution into each of the duplicate wells in Column 1 and 2. Use 7 standard points for generating a standard curve: 0, 5, 10, 25, 50, 75, 100 nmol/well. Leave well 1H and 2H for blank controls.
4. Add 5 µL of plasma individually into each well. Use duplicate for each sample. Set up blank controls by adding 5 µL of ddH_2O instead of plasma into well 1H and 2H. Mix the plate well by hand.
5. Incubate the plate at 37^0C for 5 minutes.
6. Cool the plate at 21^0C in the plate reader for 5 minutes.
7. Take the plate out from the plate reader. Add 40 µL of R2 into each well using a multi-channel pipettor, changing tips after each addition. Time the start of R2 addition.

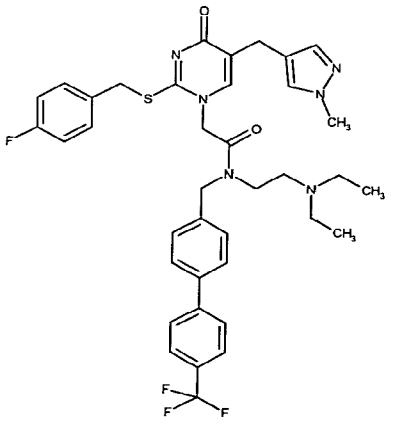
8. Add 2 μL of ethanol into each well using a multi-channel pipettor, changing tips after each addition. The purpose of this step is to rid of all the air bubbles generated in wells. The duration between first R2 addition and plate reading in Step #9 is 4 minutes.
9. Read the plate at 405nm for 20 minutes with a 2-minute interval. Include a 2-minute auto-mixing before reading the plate.

Activity Calculation

1. Generate a standard curve by plotting average OD values at 0 and 20 minutes (OD_{0min} and OD_{20min}) for the 7 standards vs. p-nitrophenol (nmol/well). Calculate the slope of the standard curve.
2. Calculate ΔOD values for each blank well between 2 and 4 minutes (OD_{4min} -OD_{2min}) and average the two ΔOD values for the blanks.
3. For each sample well, calculate ΔOD values between 2 and 4 minutes and then Lp-PLA2 activity (nmol/min/ml) = (ΔOD_{sample} -ΔOD_{blank}) ÷ slope (OD/nmol) ÷ 0.005 ml ÷ 2 minutes.
4. Calculate an average activity value for duplicate sample wells.

Results

Substrate specificity against Lp-PLA2 was assayed by using two Lp-PLA2 inhibitor compounds; Formula II, which is described in Example 6, and Formula III, which is presented below:



Formula III

Formula III or 1-(N-(2-(Diethylamino)ethyl)-N-(4-(4-trifluoromethylphenyl)benzyl)aminocarbonylmethyl)-2-(4-fluorobenzyl)thio-5-(1-methylpyrazol-4-ylmethyl)pyrimidin-4-one is described in WO 00/66567.

Plasma samples from four healthy patients were incubated *in vitro* with increasing amount of Formula III. All four plasma demonstrated decreasing Lp-PLA2 activity as shown in Table 4. Inhibition achieved by Formula III in all four samples reached over 90%, comparable to the natural Lp-PLA2 substrate PAF used in the radiometric activity assay. Formula II also showed over 90% inhibition of the substrate hydrolysis when incubated *in vitro* in the same four plasma samples.

Table 4: *In Vitro* Inhibition of Lp-PLA2 Activity by Formula III in Four Plasma Samples

	Activity (nmol/min/mL)				% Inhibition			
Drug (nM)	#3	#7	#8	#10	#3	#7	#8	#10
600	22.65	10.50	9.67	10.91	88.50	92.75	90.37	93.78
60	16.25	12.64	0.14	14.17	91.75	91.28	99.86	91.92
6	48.61	31.39	21.81	35.97	75.32	78.33	78.29	79.49
0.6	102.78	78.61	50.69	83.89	47.81	45.73	49.52	52.18
0.06	167.36	119.17	83.33	148.89	15.02	17.74	17.02	15.12
0.006	162.22	138.06	95.42	178.61	17.63	4.70	4.98	-1.82
0.0006	200.97	142.36	86.67	179.17	-2.05	1.73	13.70	-2.14
0	196.94	144.86	100.42	175.42	0	0	0	0

The assay buffer used in above experiments has high content of detergent (7.5mM CHAPS and 10mM Sodium 1-nonanesulfonate). When detergent was eliminated from the assay, Formula III only inhibited about 65% of hydrolysis activity in plasma sample #10. When detergent was added in the parallel experiment inhibition of more than 95% was reached. Therefore, it appears that this substrate is specific to Lp-PLA2 only when it is assayed in the presence of buffer comprising detergent, as shown in Table 5.

Table 5: Effect of Detergent on Substrate Specificity

Drug (nM)	% Inhibition	
	with detergent	without detergent
60000	96.01	68.01
6000	95.68	62.73
600	95.06	61.30
60	87.94	55.03
6	76.92	54.97
0.6	69.90	46.52
0.06	48.58	26.96
0.006	24.22	26.65
0.0006	19.18	19.88
0.00006	10.68	7.20
0	0	0

Example 8: Drug Sensitive Colorimetric Assay for Measurement of Lp-PLA2 Activity

For the Auto PAF AH assay, plasma samples are diluted about 160-fold and the substrate is used at a concentration higher than its Km. It appears that when the concentration of substrate is higher than its Km the substrate competes with drug bound to Lp-PLA2 and promotes drug dissociation from the enzyme. For instance, the substrate concentration used in the Auto PAF AH assay is 1100 μM, which is more than 5 times higher than its Km (Km is about 200 μM when plasma is used as the enzyme source and assayed by Auto PAF AH protocol, see Example 1). Pre-incubation of plasma with buffer R1 in Auto PAF AH assay also appears to promote drug dissociation before the start of assay reaction. Therefore, the assays of the present invention was modified by using higher plasma sample volumes and lower substrate concentrations compared with the Auto PAF AH assay. Additionally, the pre-incubation step of plasma with R1 prior to substrate addition was eliminated. Moreover, elimination of buffer R2A increased reaction rates, which in turn enabled the use of lower substrate concentrations and a shorter assay incubation time during which drug dissociates compared with the Auto PAF AH assay

Materials

R1: 200mM HEPES, 200mM NaCl, 5mM EDTA, 10mM CHAPS, 10mM sodium 1-nonanesulfonate, pH 7.6

R2B: 90 mM 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine

p-nitrophenol: Sigma-Aldrich Chemical Co., St. Louis, MO (Cat #1048-25G)

Reagent Preparation

Assay buffer: Mix R2B and R1 in a ratio of 0.66 µL to 110 µL. Store on ice or at 4^0C. Prepare immediately before use.

p-Nitrophenol standards: Prepare 1M p-nitrophenol in methanol. Dilute 100, 75, 50, 25, 10 and 5 µL of 1M p-nitrophenol to 1 mL in methanol to prepare 100, 75, 50, 25, 10 and 5 nmol/ µL stock solutions, respectively. Prepare working solutions for each standard by diluting 40 µL of stock solution into 960 µL of methanol (1:25 dilution). Store stock and working solutions at 4^0C.

Assay Procedure

1. Add 120 µL of assay buffer to each well in a 96-well V-bottom plate (Costar 3897, Corning, Inc., Corning, NY) using a multi-channel pipettor or robot.
2. Add 25 µL of p-nitrophenol standard working solution into duplicate wells in columns 1 and 2 on another 96-well flat-bottom plate (Costar 9017, Corning, Inc., Corning, NY). Use 7 standard points for generating a standard curve: 0, 5, 10, 25, 50, 75, 100 nmol/well. Add 25 µL of PBS into well 1H and 2H for blank controls.
3. Briefly centrifuge plasma to spin down fibrin clot/particles. Add 25 µL of plasma per well in columns 3-12 on the same flat-bottom plate containing p-nitrophenol standards. Use duplicates for each sample.
4. Use a multi-channel pipettor or a robot to transfer 110 µL of assay buffer from the V-bottom plate to the flat-bottom assay plate containing plasma samples and p-nitrophenol standards. A Zymark RapidPlate can perform this step without generating bubbles in the wells. Other transfer methods may generate bubbles due to the high detergent content of R1. A small volume of ethanol can be used to eliminate air bubbles.
5. Immediately place the assay plate onto the plate reader (SPECTRAmax® PLUS^{384} UV/VIS Microplate Spectrophotometer, Molecular Devices, Sunnyvale CA) and auto-mix for 15 seconds.

6. Read the plate at 405 nm for 10 minutes at 1-minute intervals at room temperature. The duration between the start of enzymatic reaction (addition of assay buffer to the assay plate) and completion of the first absorbance reading is 1 minute.

The assay may be performed at room temperature. More stringent temperature control may be required if room temperature fluctuates within or between labs.

Activity Calculation

1. Generate a standard curve by plotting average OD values at 0 and 10 minutes (OD_{0min} and OD_{10min}) for the seven standards vs. p-nitrophenol (nmol/well). Calculate the slope of the standard curve.
2. Calculate Change in (ΔOD) values for each blank well between 1 and 3 minutes (OD_{3min} -OD_{1min}) and average the two ΔOD values for the blanks.
3. For each sample well, calculate ΔOD values between 1 and 3 minutes and then Lp-PLA2 activity (nmol/min/ml) = (ΔOD_{sample} -ΔOD_{blank}) ÷ slope (OD/nmol) ÷ 0.025 ml ÷ 2 minutes.
4. Calculate an average activity value for duplicate sample wells.

Example 9: Comparison of Radiometric Measurement Versus Colorimetric Measurement of Lp-PLA2 activity in the Presence of Lp-PLA2 Inhibitor

Lp-PLA2 activity from blood plasma samples obtained from a healthy human subject administered an Lp-PLA2 inhibitor was measured using the high throughput radiometric assay described in Example 2 and the methods of Example 8 with the following minor changes. The volume of plasma used per well was 25 μL. Substrate concentration was1125μM, and, 2 μL of substrate solution R2B was mixed in 40 μL of R2A before further mixing with 95 μL of R1 to make the assay buffer. Blood samples were collected at five timepoints after dosing (0.5, 1.0, 6.0, 48 and 96 hours post dosing). Both radiometric and colorimetric assays were used to determine Lp-PLA2 activity as well as percent inhibition in each sample as shown in Table 6. As shown in Table 6, percent inhibition of Lp-PLA2 activity as measured by a radiometric assay showed peak inhibition as about 94% one hour after dosing

while the colorimetric assay showed peak inhibition at the 6-hour timepoint with about 64% inhibition in activity. These data demonstrate that both methods can be used to measure the inhibition of Lp-PLA2 activity in samples obtained from an animal that has been administered an Lp-PLA2 inhibitor. Blood samples from humans are considered to be essentially free of Lp-PLA2 inhibitor 96 hours post dosing.

Table 6: Comparison of Lp-PLA2 Activity as Measured Using Radiometric versus Colorimetric Assay

Time Point (hour)	Radiometric Assay		Colorimetric Assay	
	Activity (nmol/min/mL)	% Inhibition (96hr-100%)	Activity (milliOD/min)	% Inhibition (96hr-100%)
0.5	28.02	47.00	34.47	36.55
1	3.19	93.97	22.98	57.70
6	10.14	80.83	19.8	63.56
48	44.52	15.80	33.76	37.86
96	52.87	0	54.33	0

Example 10: Testing of Plasma Samples from a Clinical Study for Lp-PLA2 Inhibition

Four human subjects recruited in a clinical trial of a novel Lp-PLA2 inhibitor, Formula I (see Example 5) received different doses of the drug. Drug dose for Subject #13, #36, #24, and #41 was 80 mg, 120 mg, 180 mg, and 240 mg, respectively. Plasma was collected at 0, 0.5, 1, and 3 hours after drug administration. Lp-PLA2 activity of these plasma samples was assayed by the low throughput radiometric assay described in Example 4, the Auto PAF AH assay, described in Example 1, and modified drug-sensitive colorimetric assay, which is described in this Example 8. While the radiometric activity assay indicated >90% inhibition of Lp-PLA2 activity 3 hours after dosing in all four subjects, the Auto PAF AH assay failed to indicate drug inhibition. However, the modified drug-sensitive colorimetric assay indicated 85-90% drug inhibition as shown in Table 7.

Table 7: Percent Inhibition of Lp-PLA2 Activity in Plasma Samples from Subjects Administered Lp-PLA2 Inhibitor

	% Inhibition											
Time (hr)	Radiometric Assay				Auto PAF AH Assay				Drug-Sensitive Colorimetric Assay			
Pt. No.	**13**	**36**	**24**	**41**	**13**	**36**	**24**	**41**	**13**	**36**	**24**	**41**
0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	46.12	45.06	9.58	26.68	5.60	8.38	6.26	8.60	32.82	45.62	6.73	18.41
1	81.79	91.46	90.98	88.27	9.98	14.03	11.53	14.55	73.08	84.97	86.26	77.78
3	93.74	94.36	97.32	96.02	7.11	10.93	10.36	15.70	85.64	85.3	89.15	88.37

Similarly, both the radiometric assay and the modified drug-sensitive colorimetric assay showed a measured time-dependent effect on Lp-PLA2 activity after dosing with Lp-PLA2 inhibitor as shown in Table 8. Little effect on Lp-PLA2 activity was observed using the Auto PAF AH assay as shown in Table 8.

Table 8: Lp-PLA2 Activity in Plasma Samples from Subjects Administered Lp-PLA2 Inhibitor

	Lp-PLA2 Activity (nmol/min/mL)											
Time (hr)	Radiometric Assay				Auto PAF AH Assay				Drug-Sensitive Colorimetric Assay			
Pt. No.	**13**	**36**	**24**	**41**	**13**	**36**	**24**	**41**	**13**	**36**	**24**	**41**
0	27.3	26.94	39.13	46.97	330.50	605.00	511.50	274.50	96.9	83.84	177.63	176.2
0.5	14.71	14.8	35.38	34.44	312.00	553.00	479.50	251.50	65.1	45.59	165.67	143.76
1	4.97	2.3	3.53	5.51	297.50	517.00	452.50	236.00	26.08	12.61	24.41	39.14
3	1.71	1.52	1.05	1.87	307.00	510.00	458.50	244.50	13.92	12.33	19.27	20.49

Although the activity values generated from radiometric and drug-sensitive colorimetric assay are different, correlation between the two assays is r=0.975 for these 16 clinical plasma samples. Therefore, the modified drug-sensitive colorimetric assay, described herein, although using the same substrate as the Auto PAF AH assay, demonstrated ability to detect *in vivo* drug inhibition of Lp-PLA2 in drug-treated human subjects, while the Auto PAF AH assay did not.

Example 11: Testing of Additional Plasma Samples from a Clincal Study for Lp-PLA2 inhibition

Plasma samples were collected from ten subjects in a clinical trial for the Lp-PLA2 inhibitor of Formula I. Subjects #109, #114, #115, #142 and #145 received 50 mg of Formula I while subjects #118, #119, #121, #123 and #124 received 120 mg of the compound. Lp-PLA2 activity of these plasma samples were assayed by

the high throughput radiometric assay as described in Example 4, the Auto PAF AH assay as described in Example 1, and modified drug-sensitive colorimetric assay as described in Example 8. Consistently, the Auto PAF AH assay failed to measure drug inhibition of Lp-PLA2 activity in these samples with maximal inhibition of 29% detected in subject #123. Meanwhile, the drug-sensitive colorimetric assay indicated comparable drug inhibition with radiometric assay in all subjects. Inhibition values for the radiometric assay and the modified, drug-sensitive colorimetric assay agreed within 15% for all but four time (#114/12 hr, #115/12 hr, #142/0.5 hr and #142/12 hr) as shown in Table 9.

Table 9: Lp-PLA2 Activity and Percent Inhibition by Subject and Assay

		Lp-PLA2 Activity (nmol/min/mL)			% Inhibition		
Subject	Time (hr)	Radiometric	Auto PAF AH	Drug-Sensitive Colorimetric	Radiometric	Auto PAF AH	Drug-Sensitive Colorimetric
# 109	0	140.47	703.50	193.21	0.00	0.00	0.00
	0.5	104.52	647.00	141.14	25.59	8.03	26.95
	1	26.80	605.00	39.10	80.92	14.00	79.76
	2	14.51	559.50	30.57	89.67	20.47	84.18
	3	18.06	602.50	35.03	87.14	14.36	81.87
	4	20.76	629.50	33.46	85.22	10.52	82.68
	5	19.57	651.50	31.77	86.07	7.39	83.55
	6	21.78	642.00	66.08	84.49	8.74	65.80
	9	32.01	571.50	49.86	77.21	18.76	74.19
	12	35.85	571.50	76.84	74.48	18.76	60.23
#114	0	84.01	512.00	127.01	0.00	0.00	0.00
	0.5	65.24	456.50	89.99	22.34	10.84	29.15
	1	18.68	414.50	24.96	77.76	19.04	80.35
	2	14.34	406.50	21.22	82.93	20.61	83.29
	3	12.24	435.00	18.66	85.43	15.04	85.31
	4	13.50	409.00	18.15	83.93	20.12	85.71
	5	14.14	385.00	16.58	83.17	24.80	86.94
	6	16.10	388.50	21.01	80.84	24.12	83.46
	9	24.73	445.50	37.35	70.56	12.99	70.59
	12	28.82	409.50	111.00	65.69	20.02	12.60
#115	0	60.58	310.00	83.99	0.00	0.00	0.00
	0.5	50.18	308.00	69.79	17.17	0.65	16.91
	1	10.60	242.00	22.46	82.50	21.94	73.26
	2	10.00	282.00	16.31	83.49	9.03	80.58
	3	13.03	287.50	21.31	78.49	7.26	74.62
	4	14.37	309.00	21.77	76.28	0.32	74.08
	5	13.63	279.50	15.83	77.50	9.84	81.16
	6	15.96	306.50	25.84	73.65	1.13	69.24
	9	25.91	289.50	36.27	57.23	6.61	56.82
	12	26.92	336.00	53.72	55.56	-8.39	36.04

Subject	Time (hr)	Lp-PLA2 Activity (nmol/min/mL)			% Inhibition		
		Radiometric	Auto PAF AH	Drug-Sensitive Colorimetric	Radiometric	Auto PAF AH	Drug-Sensitive Colorimetric
#118	0	101.65	382.50	102.59	0.00	0.00	0.00
	0.5	35.83	323.50	31.08	64.75	15.42	69.70
	1	16.73	334.00	19.69	83.54	12.68	80.81
	2	13.70	313.50	19.69	86.52	18.04	80.81
	3	14.09	335.00	13.17	86.14	12.42	87.16
	4	14.00	346.50	7.30	86.23	9.41	92.88
	5	14.05	353.50	22.94	86.18	7.58	77.64
	6	15.68	330.00	20.65	84.57	13.73	79.87
	9	21.11	338.00	27.16	79.23	11.63	73.52
	12	24.22	355.50	38.74	76.17	7.06	62.24
#119	0	141.40	736.00	180.59	0.00	0.00	0.00
	0.5	25.97	596.50	20.14	81.63	18.95	88.89
	1	16.04	568.00	23.29	88.66	22.83	87.10
	2	13.50	579.00	19.54	90.45	21.33	89.18
	3	12.80	616.50	20.61	90.95	16.24	88.59
	4	12.85	597.50	21.27	90.91	18.82	88.22
	5	11.69	748.00	21.36	91.73	-1.63	88.17
	6	11.41	714.00	21.39	91.93	2.99	88.16
	9	18.51	578.50	27.87	86.91	21.40	84.57
	12	21.27	607.50	38.46	84.96	17.46	78.70
#121	0	97.09	440.50	134.39	0.00	0.00	0.00
	0.5	16.07	402.00	19.87	83.45	8.74	85.22
	1	10.00	401.00	14.99	89.70	8.97	88.85
	2	10.00	402.50	12.22	89.70	8.63	90.90
	3	10.00	414.50	15.08	89.70	5.90	88.78
	4	10.00	389.50	16.18	89.70	11.58	87.96
	5	10.00	416.00	18.14	89.70	5.56	86.50
	6	10.26	412.00	18.74	89.43	6.47	86.06
	9	14.41	428.00	26.18	85.16	2.84	80.52
	12	16.97	456.00	35.87	82.52	-3.52	73.31
#123	0	72.11	454.00	116.90	0.00	0.00	0.00
	0.5	39.68	410.50	63.95	44.97	9.58	45.29
	1	19.83	402.50	30.22	72.50	11.34	74.15
	2	19.42	369.50	29.51	73.07	18.61	74.76
	3	21.08	387.50	30.49	70.77	14.65	73.92
	4	19.51	406.50	29.42	72.94	10.46	74.84
	5	20.24	428.50	35.46	71.93	5.62	69.67
	6	19.66	393.00	39.29	72.74	13.44	66.39
	9	32.48	343.00	50.81	54.96	24.45	56.54
	12	34.26	324.00	61.16	52.49	28.63	47.69

Subject	Time (hr)	Lp-PLA2 Activity (nmol/min/mL)			% Inhibition		
		Radiometric	Auto PAF AH	Drug-Sensitive Colorimetric	Radiometric	Auto PAF AH	Drug-Sensitive Colorimetric
#124	0	87.96	465.50	109.88	0.00	0.00	0.00
	0.5	58.09	434.50	64.40	33.96	6.66	41.39
	1	12.39	429.50	18.74	85.91	7.73	82.95
	2	10.00	367.50	10.11	88.63	21.05	90.80
	3	10.00	362.50	11.51	88.63	22.13	89.53
	4	10.00	403.00	11.21	88.63	13.43	89.80
	5	10.00	377.00	12.22	88.63	19.01	88.88
	6	10.00	366.00	17.01	88.63	21.37	84.52
	9	11.21	387.00	21.03	87.26	16.86	80.86
	12	15.69	355.00	30.70	82.16	23.74	72.06
	0	77.38	368.50	100.48	0.00	0.00	0.00
#142	0.5	78.40	393.00	81.70	-1.32	-6.65	18.69
	1	30.87	340.50	37.07	60.11	7.60	63.11
	2	14.73	348.00	27.05	80.96	5.56	73.08
	3	12.41	348.00	22.64	83.96	5.56	77.47
	4	11.47	338.50	19.97	85.18	8.14	80.12
	5	10.66	336.50	18.35	86.22	8.68	81.74
	6	12.93	325.00	25.12	83.29	11.80	75.00
	9	22.03	312.00	38.84	71.53	15.33	61.34
	12	21.96	307.00	44.60	71.62	16.69	55.61
#145	0	63.55	305.00	88.69	0.00	0.00	0.00
	0.5	22.46	272.50	32.96	64.66	10.66	62.84
	1	15.85	271.00	17.15	75.06	11.15	80.66
	2	14.45	271.50	21.07	77.26	10.98	76.24
	3	11.99	277.50	20.89	81.13	9.02	76.45
	4	10.02	256.50	19.02	84.23	15.90	78.55
	5	10.14	273.50	20.74	84.04	10.33	76.62
	6	11.33	273.50	23.71	82.17	10.33	73.27
	9	17.58	286.00	33.36	72.34	6.23	62.39
	12	20.83	261.50	34.83	67.22	14.26	60.73

Correlation of r=0.95 was obtained between the modified, drug-sensitive colorimetric assay and the radiometric assay for the 100 samples analyzed in this study. The Auto PAF AH assay showed poor correlation with radiometric assay in these drug dosed samples (r=0.31).

Example 12: Assay Dynamic Range

Instrument Low Limit of Quantitation

Twenty-five microliters of PBS were added into 110 µL of R1 containing 0.67 µL of R2B. Sixteen replicates were prepared and randomly placed in wells across a microtiter plate. Absorbance at 405 nm was obtained and standard

deviation calculated between replicates. Six times standard deviation (6 x SD) was defined as the lower limit of quantitation for the microtiter plate reader (SPECTRAmax® PLUS^{384} UV/VIS Microplate Spectrophotometer, Molecular Devices, Sunnyvale, CA). The average OD reading from 16 replicates was 0.0437 with a standard deviation of 0.0009. The lower limit of quantitation for the microtiter plate reader was defined as 6 x 0.0009 or a change of 0.0054 OD units during assay incubation.

Linear Detection Range of p-Nitrophenol

Serial dilutions of p-nitrophenol were prepared in methanol. Twenty-five microliters of p-nitrophenol at each concentration were added to 110 µl R1 (without R2B) in a microtiter plate. Absorbance values at 405 nm were linear between 0.05 to 125 nmol of p-nitrophenol (r = 0.996). However, the blank corrected absorbance of the 0.05 nmol p-nitrophenol sample was only 0.00415, which is below the microtiter plate reader's lower limit of quantitation of 0.0054 OD as defined above. Therefore, the linear detection range of p-nitrophenol is set between 0.1 and 125 nmol of p-nitrophenol per well.

Example 13: Effect of Pre-incubation of Human Plasma with Buffer R1 on Drug-sensitivity

In the Auto PAF AH assay, plasma is pre-incubated in buffer R1 at 37^{0}C for 5 minutes. This pre-incubation step may accelerate the dissociation of drug bound to Lp-PLA2 before the start of the reaction. To test whether accelerated dissociation occurs, a plasma sample from a human subject (#10) was incubated with increasing amount of Lp-PLA2 inhibitor at 37^{0}C for an hour. Twenty-five microliters of the *in vitro* drug-treated plasma was then pre-incubated with 100 µL R1 at room temperature for different times before running the assay for 10 minutes at room temperature after addition of 40 µl of R2 (final substrate concentration of 1100 µM). Pre-incubation of plasma with R1 decreased drug-inhibition especially at lower drug concentrations. The highest level of drug inhibition was obtained when R1 and R2 were premixed and added directly to plasma without pre-incubation, as shown in Table 10. Pre-incubation of plasma in R1 at 37^{0}C instead of room temperature further deteriorates drug inhibition.

Table 10: Effect of Preincubation of Plasma in Buffer R1 on Percent Inhibition of Lp-PLA2 Activity

	Preincubation of Plasma in R1 Buffer Reaction Time (minutes)			
Drug (ng/mL)	5 minutes	2 minutes	0 minutes	R1R2 premix
0	0.00	0.00	0.00	0.00
2	-2.33	3.94	10.76	15.10
5	2.39	4.83	17.18	25.76
10	9.35	10.03	18.97	27.17
30	35.14	42.02	45.19	53.92
60	39.97	39.17	49.00	57.64
90	72.26	72.58	76.61	77.69

Example 14: Effect of Substrate Concentration on drug-sensitivity

The substrate concentration is 1100 μM in the Auto PAF AH assay, which is more than 5 times higher than its Km (Km = 200 μM when plasma is used as the enzyme source and assayed by Auto PAF AH protocol). High substrate concentrations may compete with drug binding to Lp-PLA2. To test this possibility, 25 μL of an *in vitro* Lp-PLA2 inhibitor treated human plasma samples were added to premixed R1 (100 μL) and R2 (40 μL) containing different amounts of the substrate. Substrate hydrolysis was immediately monitored at room temperature for 10 minutes. Lower substrate concentrations indicate greater drug inhibition. Activity values approached the lower limit of quantitation at the higher drug levels when the substrate was used at 154 μM or less due to slower hydrolysis rates. Consequently, the substrate concentration should be maintained slightly above its Km in order to drive rapid substrate hydrolysis while maintaining drug inhibition levels, as shown in Table 11.

Table 11: Effect of Substrate Concentration on Percent Inhibition of Lp-PLA2 Activity

	Substrate Concentration (uM)			
Drug (ng/mL)	275	550	1100	2200
0	0.00	0.00	0.00	0.00
2	32.43	26.84	18.32	17.33
5	31.02	34.92	16.53	30.96
10	51.38	50.23	25.26	42.68
30	67.57	56.99	46.00	28.30
60	76.88	72.98	59.86	52.77
90	86.12	81.83	71.89	70.69

Example 15: Effect of Human Plasma Sample Volume on Drug-sensitivity

Two μL of plasma were assayed in a 320 μL reaction for the Auto PAF AH assay, which corresponds to a plasma dilution factor of 160-fold. High plasma dilution may promote drug dissociation from Lp-PLA2. Consequently, 5 to 50 μL of an *in vitro* Lp-PLA2 inhibitor treated plasma sample were diluted with varying volumes of R1 and 40 μL of R2 to a final volume of 165 μL containing 1100 μM substrate. Hydrolysis was immediately monitored at room temperature for 10 minutes. Greater drug inhibition was observed with higher plasma sample volumes, as shown in Table 12.

Table 12: Effect of Sample Volume on Percent Inhibition of Lp-PLA2 activity

	Plasma Sample Volume (μL)			
Drug (ng/mL)	5	15	25	50
0	0.00	0.00	0.00	0.00
2	88.47	4.15	18.32	13.22
5	09.11	19.85	16.53	10.26
10	-14.73	39.11	25.26	33.03
30	33.90	23.53	46.00	55.58
60	34.14	56.68	59.86	67.68
90	43.78	62.68	71.89	79.14

Example 16: Effect of Deletion of Buffer 2A on Drug-sensitivity

In the Auto PAF AH assay, the substrate stock solution R2B is premixed in buffer R2A (20 mM citric acid monohydrate, 10 mM sodium 1-nonanesulfonate, pH 4.5), which acts as a substrate stabilizer. The substrate, after diluted in R2A, remains stable at 4^0C for 14 days. Faster hydrolysis rate was observed when R2A was omitted from the assay. For example, the colorimetric assay was performed with 180 nmol of substrate (2 μL of R2B) and either 25 μL or 50 μL of plasma. Additionally, samples contained either 0 μL or 40 μL of R2A. All reactions were diluted to either 125μl or 165 μL with R1. Buffer components were pre-mixed and the reaction was initiated upon human plasma addition. Substrate hydrolysis was immediately monitored at room temperature for 10 minutes. Vmax (milliOD/min) was calculated and compared among different conditions. Higher hydrolysis rates were observed upon omission of R2A, independent of plasma volume as shown in Table 13.

Table 13: Effect of the Deletion of Buffer R2A from the Assay

	Sample					
	1	2	3	4	5	6
R1	100 µL	140 µL	100 µL	75 µL	115 µL	75 µL
R2A	40 µL	0 µL	0 µL	140 µL	0 µL	0 µL
R2B	2 µL	2 µL	2 µL	2 µL	2 µL	2 µL
Plasma	25 µL	25 µL	25 µL	50 µL	50 µL	50 µL
Vmax (milliOD/Minute)	40	90	70	40	150	120

Since R2A has low pH of 4.5 compared with the other assay buffer components, whether addition of R2A affected the pH of the assay reaction was determined. The pH of assay reactions containing 110 µL of R1, 0.66 µL of R2B and 25 µL of either plasma or ddH_2O were 7.52 and 7.53, respectively. The pH dropped to 7.43 and 7.42, respectively, when 40 µL of R2A were added to these assay samples. The effect of R2A on Lp-PLA2 hydrolysis rates of the substrate is probably more than pH-related.

Elimination of R2A from the assay increased hydrolysis rates, thereby allowing the use of lower substrate concentrations and shorter assay incubation times, both of which lower drug dissociation. Lp-PLA2 activity values approached the lower limit of quantitation when 25 µL of plasma were measured using 154 µM of substrate and R2A as described in Example 14. A substrate titration experiment was repeated using 50 µL of *in vitro* Formula I-treated plasma (subject #10) and 75 µL of assay buffer containing only R1 and R2B (no R2A). Assays were monitored at room temperature for 10 minutes at 405 nm and Vmax and drug inhibition were calculated. Hydrolysis activity exceeded the lower limit of quantitation at 900 and 9000 ng/mL of drug even at substrate concentrations as low as 65 µM. Consequently, R2A was eliminated and lower substrate concentrations were incorporated in the modified colorimetric activity assay.

Table 14: Effect of Substrate Concentration on Vmax of Substrate Hydrolysis

Vmax (milliOD/min) of Substrate Hydrolysis in Absence of Buffer R2A						
Drug (ng/mL)	Substrate Concentration (uM)					
	273	205	154	115	86	65
9000	10.18	13.01	5.70	5.76	5.23	3.40
900	14.25	10.45	6.66	5.32	4.54	4.06
90	98.56	72.58	64.27	61.08	53.56	44.88
30	117.89	94.33	83.66	75.21	65.47	54.08
10	114.89	93.75	79.87	76.21	67.31	54.90
5	112.58	93.22	82.11	76.71	66.46	52.99
0	110.82	90.18	80.40	73.58	63.73	56.30

Earlier studies indicated higher drug inhibition as the substrate concentration was lowered over 2200 μM to 273 μM in combination with 25 uL of human plasma. However, no significant effect on drug inhibition was observed when substrate concentration was lowered over 273 μM to 65 μM using 50μL of plasma, which suggests drug dissociation is not promoted by lower substrate levels with higher plasma volumes over this range.

Example 17: Design of Experiment Software

After identifying individual factors that contribute to the drug insensitivity of the original Auto PAF AH assay, JMP software (Design of Experiment, herein "DOE") was used to design experiments investigating interactions between individual factors and to identify optimal combinations for detecting drug inhibition over an adequate dynamic range.

DOE experiment #1

The first DOE experiment focused on four factors including buffer R1 volume (2 levels), plasma volume (4 levels), substrate concentration (8 levels) and drug treatment (2 levels). [The indicated levels of substrate concentration refer to the substrate concentration in the aliquot of premixed R2B/R1 added to each reaction unless otherwise noted.] Although a full factorial combination of variables would require 128 assay reactions, D-optimal design suggested 48 different combinations. These 48 reactions were performed in duplicate, using a single plasma sample with or without prior *in vitro* incubation with Formula I at 37^0C for an hour. Substrate was directly diluted into R1 and plasma was then added to start hydrolysis at room

temperature. Vmax and drug inhibition were calculated based on absorbance readings at 405 nm over 5 minutes at room temperature.

JMP predicted that a combination of 15 μL or 25 μL of plasma and 110 μL of R1 containing 273 μM to 1100 μM substrate would indicate 90% or greater drug inhibition. This set of conditions would also yield reasonably high Vmax so that heavily drug-treated plasma would not fall below the lower limit of quantitation.

DOE Experiment #2

The second DOE experiment focused on the conditions identified by the prior DOE experiment. It designed a full factorial combination of all variables including R1 volume (1 level), plasma volume (2 levels), substrate concentration (4 levels) and drug treatment (4 levels). Thirty-two conditions were assayed in duplicate. The assay protocol was identical to the first DOE experiment. [The indicated levels of substrate concentration again refer to the substrate concentration in the aliquot of premixed R2B/R1 added to each reaction unless otherwise noted.] Prediction Profiler predicted that 25 μL plasma and 110 μL of R1 containing 545 μM substrate would generate a Vmax of 76 milliOD/min for non-drug treated plasma and indicate close to 95% drug inhibition for plasma treated with 900 ng/mL of drug *in vitro*. Therefore, the modified, drug-sensitive assay uses 25 μL of plasma with 110 μL of R1 containing 545 μM substrate for a final substrate concentration of 440 μM in the assay.

An alternative set of conditions was also identified (15 ul of plasma and 110 μL of R1 containing 545 μM for a final substrate concentration of 475 μM in the assay) that indicated 94% drug inhibition and Vmax = 53 milliOD/min for non-drug-treated plasma.

Example 18: Reaction Time

Four human plasma timepoint samples from a single subject, who was treated *in vivo* with Lp-PLA2 inhibitor drug, were assayed for Lp-PLA2 activity by the modified, drug-sensitive colorimetric assay containing 440 μM substrate and 25 μL of plasma (described in Example 8). The same four plasma samples were also assayed by the same assay protocol but with 50 μL of plasma and 154 μM of substrate. The first 5 minutes of hydrolysis were monitored for each reaction and five Vmax values were calculated based on time intervals of 1, 2, 3, 4 or 5 minutes

from the start of the reaction. Samples corresponding to high Lp-PLA2 inhibition (1 and 3 hour post-dose) exhibited higher Vmax values for longer assay reaction times when 25 μL plasma and 440 μM substrate were used, compared with 50 μL plasma and 154 μM substrate. This suggests drug dissociation may occur under such condition where competition between drug and substrate is relatively strong. In contrast, Vmax values for 1 and 3 hour post-dose time points were independent of assay reaction time when more plasma and lower substrate was used (e.g., 50 μL plasma/154 μM substrate). However, Vmax values tend to decreae with longer assay reaction times for samples with lower drug inhibition (0 and 0.5 hours) especially at higher plasma volume and lower substrate concentration. Therefore, assay performance is affected by at least three factors affecting three attributes:

(1) High plasma volume, short incubation time and low substrate concentration promote measurement of high levels of drug inhibition;

(2) Low plasma volume, short incubation time and high substrate concentration promote a high upper limit of quantitation;

(3) High plasma volume, long incubation time and high substrate concentration promote sensitive lower limits of quantitation.

The implementation of robotics is recommended to shorten the time between addition of substrate into plasma and the first absorbance reading on the plate reader. Current protocol assembles and mixes an entire microtiter plate of reactions and start plate reading 1 minute after starting the first reaction on the plate. Activity calculations are based on data collected during the first 2 minutes in the microtiter plate reader.

Example 20: Further Assay Testing Intra-assay variability

Intra-assay variability was assessed using plasma samples from 10 healthy (non-fasted) human subjects. Six replicates of plasma from each subject were assayed on the same assay plate. The CV for individual subjects ranged from 2.57 to 9.14% with an average intra-assay CV of 5.36% as shown in Table 15.

Table 15: Intra-Assay Validation

Lp-PLA2 Activity (nmol/min/mL)										
Replicate	Subject No.									
No.	#6954966	#5149192	#6839829	#5147931	#5181480	#5149190	#5149188	#6954955	#6955001	#6716001
1	112.26	64.53	147.94	138.05	94.56	105.37	132.26	140.35	140.56	139.30
2	115.68	78.40	137.14	135.75	93.59	97.35	109.41	135.33	124.53	145.92
3	108.92	74.29	156.52	146.62	90.45	113.87	111.78	129.55	119.30	145.30
4	113.24	74.49	174.22	143.55	93.10	102.86	107.25	138.82	116.93	140.14
5	108.01	69.62	138.47	140.28	92.82	120.07	107.87	128.85	130.31	140.14
6	113.31	80.14	146.83	145.16	91.85	114.70	112.89	134.70	136.59	147.87
Average	**111.90**	**73.58**	**150.19**	**141.57**	**92.73**	**109.04**	**113.58**	**134.60**	**128.04**	**143.11**
%CV	**2.60**	**7.81**	**9.14**	**3.00**	**1.54**	**7.84**	**8.29**	**3.48**	**7.38**	**2.57**

Inter-assay variability

Inter-assay variability was assessed using plasma samples from 10 healthy human subjects (non-fasted), assayed in three separate assays on different days. The inter-assay CV for individual plasma samples ranged from 1.90 to 23.78% with an average inter-assay CV of 7.59%. Plasma from Subject #5181480 (inter-assay CV=23.78%) had a white/turbid appearance after brief centrifugation, suggesting high lipid content in the sample as shown in Table 16.

Table 16: Inter-Assay Variability

Lp-PLA2 Activity (nmol/min/mL)										
Assay	Subject No.									
No.	#6954966	#5149192	#6839829	#5147931	#5181480	#5149190	#5149188	#6954955	#6955001	#6716001
1	111.90	73.58	150.19	141.57	92.73	109.04	113.58	134.60	128.04	143.11
2	105.75	76.77	143.36	127.71	58.21	106.36	112.86	106.26	116.87	134.58
3	117.70	83.78	147.66	118.56	70.17	97.80	116.94	120.69	130.48	134.02
Average	**111.79**	**78.04**	**147.07**	**129.28**	**73.70**	**104.40**	**114.46**	**120.52**	**125.13**	**137.24**
%CV	**5.34**	**6.69**	**2.35**	**8.96**	**23.78**	**5.62**	**1.90**	**11.76**	**5.80**	**3.71**

Inter-operator variability

Inter-operator variability was assessed using plasma samples from 10 healthy subjects assayed by three different operators on different days. The inter-operator CV for individual plasma samples ranged from 5.11 to 14.91% with an average inter-operator CV of 8.32% as shown in Table 17.

Table 17: Inter-Operator Variability

Lp-PLA2 Activity (nmol/min/mL)										
Operator	Subject No.									
No.	#6954966	#5149192	#6839829	#5147931	#5181480	#5149190	#5149188	#6954955	#6955001	#6716001
1	111.79	78.04	147.07	129.28	73.70	104.40	114.46	120.52	125.13	137.24
2	107.20	70.46	128.55	128.06	66.74	100.98	106.22	114.00	114.09	109.69
3	98.60	74.85	136.87	111.37	62.05	82.44	102.25	100.23	112.41	104.82
Average	**105.86**	**74.45**	**137.50**	**122.90**	**67.50**	**95.94**	**107.64**	**111.58**	**117.21**	**117.25**
%CV	**6.32**	**5.11**	**6.75**	**8.14**	**8.69**	**12.31**	**5.79**	**9.28**	**5.89**	**14.91**

Freeze/thaw effect

Plasma samples are normally received and stored frozen. In the case of repeat analysis, samples are commonly subject to freeze/thaw cycles. Ten plasma samples were analyzed after each of four freeze/thaw cycles. No definitive trend in Lp-PLA2 values was observed, indicating samples may be frozen and thawed four times, a shown in Table 18.

Table 18: Freeze/Thaw Effect

Lp-PLA2 Activity (nmol/min/mL)										
Freeze/	Subject No.									
Thaw	6954966	5149192	6839829	5147931	5181480	5149190	5149188	6954955	6955001	6716001
1	111.90	73.58	150.19	141.57	92.73	109.04	113.58	134.60	128.04	143.11
2	105.75	76.77	143.36	127.71	58.21	106.36	112.86	106.26	116.87	134.58
3	112.72	82.20	141.72	107.84	53.78	81.48	116.70	99.18	130.55	125.98
4	101.09	68.94	105.00	95.96	55.96	97.12	98.05	122.05	105.40	169.87
Average	**107.87**	**75.37**	**135.07**	**118.27**	**65.17**	**98.50**	**110.30**	**115.52**	**120.21**	**143.38**
%CV	**5.08**	**7.39**	**15.09**	**17.18**	**28.33**	**12.63**	**7.56**	**13.77**	**9.59**	**13.24**

All publications and references, including but not limited to patents and patent applications, cited in this specification are herein incorporated by reference in their entirety as if each individual publication or reference were specifically and individually indicated to be incorporated by reference herein as being fully set forth. Any patent application to which this application claims priority is also incorporated by reference herein in its entirety in the manner described above for publications and references.

Claims

1. A method for determining inhibition of Lp-PLA2 enzyme activity in at least one sample comprising the steps of preparing a solution comprising a substrate for Lp-PLA2 comprising a colorimetric or fluorometric detectable moiety; contacting at least one said sample with the solution of the preparing step; and detecting Lp-PLA2 activity, wherein the sample is from an animal that has been administered with Lp-PLA2 inhibitor.

2. The method of claim 1, further comprising comparing Lp-PLA2 activity from at least one second sample obtained from an animal wherein said second sample is free of said Lp-PLA2 inhibitor.

3. The method of claim 1, wherein inhibition of Lp-PLA2 activity is measured in a plurality of samples obtained from an animal at more than one time point after administration of said Lp-PLA2 inhibitor.

4. The method of claim 1, wherein the substrate is 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine.

5. The method of claim 4, wherein the 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine is at a concentration of about 154μM to about 1125μM.

6. The method of claim 5, wherein the 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine is at a concentration of about 440 μM or less.

7. The method of claim 1, wherein the sample is blood plasma.

8. The method of claim 6, wherein the blood plasma is diluted about 3 to about 9 fold with the solution of the preparing step.

9. The method of claim 1, wherein the Lp-PLA2 activity is measured by measuring optical density of the sample.

10. The method of claim 1, wherein the solution comprising a substrate for Lp-PLA2 further comprises a buffer and wherein the buffer is incubated with the substrate prior to contacting the substrate with said sample.

11. The method of claim 10, wherein the buffer does not comprise citric acid monohydrate.

12. The method of claim 1, wherein the substrate concentration is maintained at approximately the Km of said substrate.

13. The method of claim 1, the volume of plasma sample is about 15 uL to about 50 μL in a volume of about 125 μL to about 170 μL of the solution of the preparing step.

14. The method of claim 1, wherein the pH of the reaction is maintained at at least about 7.5 prior to contacting the sample with the solution of the preparing step.

15. A method for determining Lp-PLA2 enzyme activity in a sample obtained from an animal comprising the steps of:

c) contacting 110 μL of a solution comprising:

a solution comprising 90 mM 1-myristoryl-2-(4-nitrophenylsuccinyl) phosphatidylcholine contacted with a solution comprising 200mM HEPES, 200mM NaCl, 5mM EDTA, 10mM CHAPS, 10mM sodium 1-nonanesulfonate at a pH 7.6 in a ratio of 0.66 μL to 110 μL;

with at least one 25 μL tissue sample from an animal;

with 25 μL each of a p-nitrophenol standard solution comprising; 4, 3, 2, 1, 0.4 or 0.2 nmol/μL p-nitrophenol in methanol; and

25 μL of phosphate buffered saline (PBS) or ddH_2O to make a blank; and

d) determining Lp-PLA2 activity.

16. The method of claim 15, wherein the sample from animal is blood plasma.

17. The method of claim 15, wherein the animal is human.

18. The method claim 15, wherein the animal has been administered an inhibitor of Lp-PLA2 prior to obtaining the sample.

19. The method of claim 18, wherein inhibition of Lp-PLA2 enzyme activity by said Lp-PLA2 inhibitor administered prior to obtaining said sample is measured by comparing Lp-PLA2 activity of a sample free of said Lp-PLA2 inhibitor.

20. The method of claim 15, further comprising:.

e) generating a standard curve by plotting optical density (OD) values at 405 nm for the p-nitrophenol standard solutions vs. p-nitrophenol (nmol/well);

f) calculating the slope (OD/nmol) of the standard curve;

g) calculating aborbance change between 3 and 1 minute ($\Delta OD_{3min-1min}$) for both solutions comprising tissue samples and blank; and

h) calculating Lp-PLA2 activity using the following formula: Lp-PLA2 activity (nmol/min/ml) = (ΔOD_{sample} -ΔOD_{blank}) ÷ slope (OD/nmol) ÷ 0.025 ml ÷ 2 minutes.

ABSTRACT

This invention relates to methods for determining the activity of Lp-PLA2 in at least one sample from an animal. The invention also relates to methods for determining the inhibition of Lp-PLA2 activity in samples from animals that are administered an Lp-PLA2 inhibitor.